ON THE

DEVELOPMENT

OF

LOOSE CARTILAGINOUS BODIES.

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Read on Thursday, January 9, 1851.

Theories in abundance are not wanting to elucidate the mode in which loose cartilaginous bodies are formed, but unhappily, they are so varied and unsatisfactory, that the question must be considered to be nearly as far from solution as when first mooted; not that the opinions advanced are altogether erroneous, but that those which have the greatest show of probability fall short of giving any satisfactory explanation of the source of such bodies. Thus, at the dawn of pathology, Haller and others were led, from the paucity of observed facts, to consider them to be formed of pieces of articular cartilage detached by violence. This matter-of-fact doctrine was for a time discarded, when Hunter propounded his theory that they were formed of effused blood, which took on the characteristics of cartilage during its organization; for since several bodies were found in the abdomen and other serous cavities, the first explanation was found inapplicable generally. Since then there have been more conflicting statements; Béclard, Laennec, and Cruveilhier, contending that they had their origin external to the synovial membrane; while Andral and Carswell considered them to be formed in the substance of plastic lymph, or some such exudation, inflammatory or otherwise, poured out from the walls of the cavity in which they existed: detached pieces of exostosis and outgrowths from the edges of the articular cartilages have been described by Sir Benjamin Brodie and others. Now, with the exception of Hunter's, all these views are probably correct, for however contradictory they may at first appear, a more minute investigation will show that they do not in any way clash. That pieces of cartilage have been knocked from the articular surface loose into the synovial cavity is indisputable, but such occurrences are by no means frequent; so also there can be no doubt that nodules of exostosis or cartilage have occasionally grown from the articular margins, and subsequently been detached; but as such cases carry with them their own explanation, they will have no further consideration in this paper.

It is, however, with those bodies (examples of which are to be found in almost every Museum,) whose nature and structure clearly indicate an origin independent of such causes, and therefore are worthy to be classed as tumours, that we have at present to deal; and although all the bodies that are known under the name of "loose cartilages," whether found in serous or synovial cavities, will be included in the argument, yet such as are found within the articulations will occupy our chief attention, inasmuch as they have received the closest examination.

Some are osseous, some cartilaginous, partially ossified, while others more closely resemble dense fibrous tissue; the two first forms are most generally found in the articular cavities, the latter

in serous enclosures. Have these bodies an independent power of growth? To answer this question let us discuss the validity of the assertion—'the animal cell differs from that of the vegetable mainly in not having that independent vitality which the vegetable cell undeniably possesses,"—as that seems to be a stumbling-block in the way to a comprehension of the growth of all animal textures.

A vegetable cell may be said to consist of a structureless membrane, which encloses a fluid and contains a body known as the nucleus. This body is the most important part of the cell, as it is the seat of vitality, and is the acknowledged agent of growth and reproduction: the growth of the cell, which is at the same time its proper function, takes place by the imbibition, through the porous cell wall, of that material for which the nucleus possesses an attraction; in reproduction too, (or rather multiplication,) the nucleus is of equal importance, for whensoever a new cell is formed, a portion of that body is separated by a process called "spontaneous fission," and becomes the nucleus of the infant organism; this process is clearly perceptible in the single-celled algæ and fungi. It is asserted by Schleiden, that every plant developed in a higher degree than these single-celled vegetables is an aggregate of fully individualized, independent, separate beings, namely, the cells themselves; and Hunter's expression, "every part of a vegetable is a whole," forms a good background for Schleiden's opinion. But it is not supposed that conviction will follow these quotations unsupported, else might many more be cited; the power that everyone now has of investigating the minute structure of the organic kingdom by the microscope affords the greatest argument that can be addueed in favour of these views; by it can be observed in the cells of the highly developed plant, an almost exact repetition of those processes which have been mentioned as occurring in the single-celled organism, namely, growth by imbibition, and multiplication by endogenous reproduction, and fissiparation.

Schleiden further remarks, "Each cell leads a double life, an independent one, pertaining to its own development alone; and another incidental, in so far as it has become an integral part of a plant:" that is to say, besides its own peculiar vital force, it contributes by the exhibition of that force, (namely the performance of its functions) towards the vitality of the compound organism. It is not essential for our present purpose to consider the laws of vegetable cells further, nor does our argument require a substantiation of what has been already stated; but bearing in mind what is asserted for the vegetable cell, we must see whether the animal cell is governed by other, or the same laws.

An animal cell properly so called, (the agent, for instance, and not the effect of secretion,) consists of an homogeneous, structureless membrane, which encloses a fluid, and contains a nucleus; this nucleus, like that of the vegetable cell, has been considered by Professor Goodsir to be the agent by which nutritive material is attracted through the porous cell wall, and has been called by him a "centre of nutrition:" this view appears to be generally admitted, but the other property of the nucleus, that of reproduction, does not seem to be so universally allowed.

"The single-celled animal, the Gregarina," says Professor Owen, "differs from the single-celled plant by the contractility of its tissue, and the solubility of its cell wall in acetic acid;" it grows by imbibition, or endosmosis, through its investing membrane, and multiplies its species by division of its nucleus, each portion of which so divided becomes surrounded by the contraction of the enclosing tissue between them. This process, which is the counterpart of that which occurs in the single-celled algæ and fungi, takes place also in the polygastric infusoria, and has received the term of "spontaneous fission," or "fissiparation." It is clear, then, that there are some animal cells which resemble those of the vegetable in their behaviour, so to speak; and on what grounds similar conditions should be denied the individual cells of the compound animal, we shall have now to consider, and to determine whether the nucleated cell of the animal does not bear the same relation to the single-celled gregarinæ, as does the cell of the plant to the lowest form of fungus; for it cannot surely be considered preposterous to maintain the individuality of the nucleated cell, even though proof be wanting, when its descent from the im-

pregnated germ-cell is remembered, whose exhaustless influence, as evidenced in the aphides, so far exceeds the reach of finite comprehension.

Cartilage is the tissue with which we are more especially concerned in this paper, and to that alone will our attention be directed, without waiting to discuss the peculiarities of other nucleated cell structures. This tissue is comparatively simple in its structure, being made up entirely of nucleated cells imbedded in a structureless intercellular, or hyaline substance. The cells themselves closely resemble those of the vegetable; their outer cell-walls are clearly defined and homogeneous, their nuclei distinct, and their arrangement such as would indicate fissiparity, for they are found often marked with slight hour glass indentations, with half-formed diaphragms, and still more frequently are two or more of them found lying in juxtaposition with a narrow cleft between them. This notion of fissiparous reproduction is still further supported by the minute investigation of the disease known as "ulceration of cartilage," where the cells, and more especially the nuclei, divide and subdivide so rapidly as to break up the cartilage into a finely molecular condition, similar in appearance to fatty degeneration of other organs: from which we may reasonably infer that this power of reproduction is quite independent of growth, and seems to be inherited by the nucleus from the primitive germ-cell, which after impregnation so rapidly multiplies its contents without a corresponding increase of its own dimensions. Besides this power of reproduction, the cartilage cell, in common with those of all animals, possesses a power of attracting into its substance material for its development and growth, by which means the structure in which it is situated is maintained; so that it may be said to have the "double life" spoken of by Schleiden as being a characteristic of vegetable cells. How does cartilage grow? According to our argument it should be through the agency of the nuclei attracting nourishment into the hyaline substance, and from thence imbibing it for its own increase: and doubtless this is the case. But in what order are the cells developed, and whence is the material for their increase obtained?

To the first part of this question no definite answer can be given, since all cartilages have not an identical mode of growth. In ossifying cartilage, as a matter of abstract reasoning, it must be evident that as the process consumes fully developed cells, the new material essential for its continuance must be deposited beyond the seat of its action. Now it has been a matter of much dispute whether these new cells are developed at the margin or in the substance of this ossifying cartilage: a little investigation will show that both are synchronous, for in a section of the extremity of one of the long bones during its early and rapid growth can be seen the gradations from the simple, singly-nucleated, minute cells, which are to be found most remote from the part where ossification is proceeding, to the compound group of doubly nucleated and nucleolated cells formed by fissiparation, and still held together, as it were, in bundles by a faint trace of the original cell-wall. This may be observed in almost any part of the advanced fœtal skeleton; and in a transverse section of the costal cartilage prior to the development of blood-vessels within it, the marginal cells will be found to be smaller, and to contain fewer nuclei than those situated towards the centre: hence, if it be allowed that the smaller cells are the younger, to which admission it is hard to find a valid objection, we must, to a certain extent, allow cartilage to have an exogenous mode of formation; for the fact quoted in evidence of an endogenous formation,—namely, the horizontally flattened condition of the more superficial cells, supposed to be produced by pressure from within, in no way militates against the former view, but rather gives it support, by showing that the cells do not arrive at maturity soon after their production, but still go on increasing and multiplying, and thus press against and tend to flatten those more recently developed outside them. There is also good reason to believe that the permanent articular cartilage is formed in a similar manner; but whether, after having arrived at maturity, its farther nutrition is carried on by the formation of new cells, or by the mere renewal of the constitutional atoms of those already existing, is a question still to be decided, although the latter view is certainly the most reasonable. Whence is it nourished? In vascular cartilages the source is evident; but in those that receive no blood-vessels, as

the articular, it is not even now decided. It is, however, pretty generally admitted that the exudation of liquor sanguinis is all that is required, as that fluid contains all the essentials for its composition. In the articular cartilage of mammals Mr. Toynbee considers that fluid to permeate the entire thickness of the cartilage, and even a thin layer of bone, and to be drawn from the convoluted capillaries in the ends of the bone; while Dr. Leidy, in the American Journal of Medical Science, states his opinion that it is nourished by imbibition of synovia, a fluid especially rich in albumen, which he states to be the essential constituent of the tissue of cartilage. This latter opinion was suggested by Henle, and does not seem to be amenable to any grave objections, since the synovial fluid differs from the liquor sanguinis principally in being more rich in albumen, at the same time that it contains similar ingredients: it may, however, be taken as certain that true blood is not requisite for the ordinary exigencies of cartilage.

We have now theoretically a right to the following conclusions,—that cartilage by virtue of its nucleated cell structure has an independent vitality, so long as nutriment is within reach; that that food is to be found in the liquor sanguinis, and in the synovial fluid; and hence, that attachment is not essential for its maintenance.

Lest any one should be led to build up an absurdity from these observations, and infer that such a substance placed under favourable circumstances, even out of the body, ought to go on growing to eternity, it must be stated that no greater power is ascribed to cartilage than is acknowledged to be possessed by the monad or any other part of the organic kingdom, but, that in common with them, it has its stages of development, maturity, and decay; for, by the laws of all organised matter, exhaustion is an essential concomitant of vital independence.

We must now turn to the practical bearing of these conclusions on the bodies whose nature we are discussing, and see how far their structure supports the speculations the obscurity of their origin has given rise to. They are common; for there is scarcely a patho logical museum that does not possess specimens of cartilaginous bodies found in joints, either swinging freely in the cavity by a slender pedicle, and covered by synovial membrane; or, as often, perfectly unattached: they have no definite shape, those found in the larger cavities, such as the peritoneal, are for the most part of a round or oval figure, while those subject to pressure, as in the knee or other joints, have oftentimes a more or less flattened form: those found in joints moreover have generally an irregular or nodulated surface, while those of serous cavities are more smooth in their outline. As has been before stated, these bodies vary in density; sometimes, particularly in aged people, they are totally ossified, at others they have a cartilaginous coating. Among a cluster of them, whose average size was that of a walnut, found loose in the hip-joint of an old person, not one of them had any trace of recent cartilage. In a section of one, spots of softening were found scattered through its substance, and there the structure was converted into a cretaceous paste; there was no appearance of concentrically arranged lamellæ, nor to the naked eye was any definite structure visible; a transparent section, however, by the aid of the microscope clearly showed that the calcareous matter had been deposited in a cartilaginous basis, although there was not much uniformity of structure; for in parts the configuration of cells, (large, and mostly round,) irregularly scattered through a densely granulous bed, was clearly traceable; some stood alone, some in groups; they contained one, two, or more calcareous nuclei, and such as were translucent presented under certain focal conditions a radiating refraction. In some, the nuclei were distinctly stellate, while others were so choked with earthy deposit as to present no other indication of the position of the nucleus than a maximum of opacity: branched bone corpuscles were found assembled in various parts, without any trace of surrounding cells.

In another case, where two loose bodies were removed by operation from the knee of a middle-aged man, a section of the largest, which was nearly the size of a bantam's egg, presented an appearance of concentric formation; the centre was soft and had a gelatinous aspect, and around it was compact osseous matter, marked in close circling lines by an alternation of its density; the whole was surrounded by a thin layer of elastic

unossified cartilage. Under the microscope the cartilage cells were found to be assembled in linear groups, and seemed as though strung together; each cluster was enclosed in a dark indistinct envelope, which was visible only when the cells themselves were out of focus: these groups were parallel to one another and to the circumference of the mass: the cells themselves were of various sizes and shapes, and where their walls approximated one another they were flattened; they contained one, two, or more nuclei, and occasionally distinct nucleoli: the nuclei themselves had, for the most part, an irregular, nodulated outline, and refracted light brightly but in many points: the basis substance was finely granulous, and contained earthy accumulation in various parts. Ossification seemed to take place by the deposition of earthy particles within the outer cell wall chiefly. A transparent section of the ossified portion showed true bone-corpuscles having a concentric arrangement,—not however around tubes, as in healthy bone, but regularly around one common centre: they were more closely crowded in some places than others, and thereby gave a ringed appearance to the naked eye. Although dissimilar in structure, these were undeniably samples of true cartilage, the first having its type in abnormal cartilaginous productions, such as enchondroma, &c., the latter more nearly resembling natural ossifying cartilage: in neither was there any trace of vessels of any kind; nor had either any neck, or positive mark of previous attachment But let us suppose that they had, and let us, with Cruveilhier, believe that they were first formed outside the synovial membrane; how will this further our knowledge of their growth?

That they can arrive at a considerable size without blood-vessels must surely be granted, since many forms of normal cartilage are acknowledged to be devoid of them, and the examination of the foregoing samples shows that some at least present no trace of their existence: hence if there be no source of nuturient within, the material for increase must be obtained from without, and so the growth be carried on by external addition,—a view strongly supported by the structure of the second specimen: in which case, so long as the body remains in the tissues surrounding the joint, its nourishment must be obtained from them, or their vessels; but, as soon as it is protruded within the cavity, it must either cease to grow, or acquire substance from some other source. Now if, as Dr. Leidy asserts, the synovial fluid does contain all the constituents of cartilage, which is more than probable, there can be no hindrance to the continued growth of the body so displaced. It may, however, be objected, that the synovia does not contain earthy matter in quantity proportionate with the amount found in these bodies, and if rapidity of growth were asserted, (a point denied by the comparative thinness of the cartilaginous coating in the second specimen) the objection would hold good, but phosphates of lime and magnesia exist in the synovial as well as in all the serous fluids, and the irritation a foreign body would cause in the cavity of a joint would doubtless occasion an increase in the secretion. If this be so, it becomes manifest that the attachment of the bodies to the walls of the cavities in which they lie can have nothing to do with their growth or production, but that they merely prove them to have originated exterior to the lining membrane, in which case they can differ in no especial degree from the loose unattached ones found in similar cavities; and what is argued for the one must be equally applicable to the other.

Whether found in the sheaths of tendons, in joints, or in serous cavities, whether fibro-cartilaginous or cartilage, all the substances known as loose cartilages are included in these arguments, since they originate in nucleated cell structures; for if our reasoning be substantial, all that is required is a separation of a nucleus, or germ, and its deposition within reach of food; but how this separation takes place is at present difficult of solution. Cruveilhier imagined the gelatiniform cysts, that he occasionally found in the neighbourhood of joints, to be the source of these formations; and the view has some show of reason, inasmuch as the "chorda dorsalis" or "notochord" is in like manner a transparent gelatinous mass prior to the development of cartilage within it. Andral, and Carswell also, without denying that they are occasionally so produced, incline to the belief that their matrix is thrown out from the walls of the cavity in which they are

found in the shape of plastic lymph or some such exudation. But however probable these conjectures may be, no satisfactory conclusion can be obtained until these cysts have been subjected to rigid microscopic examination.

Note.—Since the foregoing was read to the Society, the writer has become acquainted with Rokitansky's* explanation of the manner in which cysts are formed; namely, by the enlargement of some cell, nucleus, or germ, which takes on an independent sphere of action,—deviates from its prescribed law: this is no mere speculation, but has been practically demonstrated, and bears strongly upon the views inculcated above; for add fissiparation to this power of increase, and a tumour results. The remarks of Mr. Paget* strongly confirm this:—"Important as the history of cysts may be in its direct bearing, yet these are not all that we may observe in it. In their history I cannot but think we may discern an image of the first form and early progress of many innocent solid tumours also. For as the cyst is traced from the mere nucleus, or even from the granule, onward to its extreme size or complexity of structure or contents, so it is very probable from the numerous correspondences between them that these solid tumours also have a similar beginning in some detached element, a tissue germ, or in some group of such germs, which in their development and growth may coalesce, and then may appropriate, or exclude for absorption the intervening substance."

* Ueber die Cyste, 1849.

* Lectures on Tumours, at Royal College of Surgeons, MEDICAL GAZETTE, p. 990, vol. xlvii.